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August 20, 2003
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SUBMISSION OF VERIFIED TRANSLATION OF JP 11-196736/1999

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Dear Sir:

Applicants submit the attached verified translation of JP 11-196736/1999 as a true and correct translation as stated in the attached Certificate signed by the translator.

Respectfully submitted,

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CERTIFICATION OF TRANSLATION

I, Masaki Morioka, residing at Toyo Bldg., 4th Floor, 16-5 Shimizu 1-Chome, Suginami-ku, Tokyo, 167-0033, Japan, and being fully conversant in both the Japanese Language and the English Language hereby certify that the annexed is a true translation into the English Language of Japanese Patent Application No. Hei 11-196736/1999 filed in the Japanese Patent Office on July 9, 1999.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Masaki Morioka

Masaki Morioka

Dated this 13th day of August, 2003

(TRANSLATION)

PATENT OFFICE

JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Applicant: Fijitsu Limited

February 14, 2000

Commissioner,
Patent Office Takahiko Kondo

Certificate No. 2000-3006762

Hei 11-196736

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[Title of the Invention] Liquid Crystal Display

[Claims]

[Claim 1]

A liquid crystal display comprising:

a first substrate having a first electrode;

a second substrate having a second electrode corresponding to a pixel;

a liquid crystal having negative dielectric anisotropy sealed between the first and the second substrates; and

a structure which is provided on each of the first and the second substrates to control an alignment of the liquid crystal;

wherein the structure on the first substrate has a linear protrusion structure, at least two auxiliary protrusion structures extending from the protrusion structure and opposing to each of facing end portions of the second electrode, and a width of the two auxiliary protrusion structures facing the second electrode is 6 μm or more.

[Claim 2]

A liquid crystal display comprising:

a first substrate having a first electrode;

a second substrate having a second electrode corresponding to a pixel;

a liquid crystal having negative dielectric anisotropy sealed between the first and the second substrates; and

a structure arranged on each of the first and the second substrates to control an alignment of the liquid crystal;

wherein the structure on the first substrate has a linear protrusion structure arranged diagonally to the pixel, and at

least a part of end portions of the second electrode being in the area decided by the protrusion structure and the structure on the second substrate and forming an obtuse angle with the protrusion structure extends outside.

[Claim 3]

A liquid crystal display in claim 2; wherein the auxiliary protrusion structure extending from the protrusion structure is opposed to an extending portion of the second electrode.

[Claim 4]

A liquid crystal display in claim 2; wherein the extending portion of the second electrode has a portion overlapping wirings formed on the second substrate via an insulating film.

[Detailed Description of the Invention]

[0001]

[Technical field to which invention belongs]

The present invention relates to a liquid crystal display for a television, display and the like. Specifically, the present invention relates to a liquid crystal display containing a vertical alignment liquid crystal with large viewing angle.

[0002]

[Prior Art]

The liquid crystal display contains the liquid crystal inserted between a pair of substrates. Each of the pair of substrates has an electrode and an alignment film. A TN (Twisted Nematic) mode liquid crystal display widely used in the past contains the liquid crystal having a horizontal alignment film and positive dielectric anisotropy, and when no voltage is applied, the liquid crystal is aligned substantially parallel to the

horizontal alignment film. When voltage is applied, the liquid crystal arises in the direction substantially perpendicular to the horizontal alignment film.

[0003]

Although the TN mode liquid crystal display has advantages such as a capability of miniaturization, the TN mode liquid crystal display has disadvantages that, first, the viewing angle is narrow and, second, contrast is low. As a method to improve the first disadvantage and to obtain the larger viewing angle, there is an alignment division. According to the alignment division, a single pixel is divided into two areas and the liquid crystal is made to arise and lie down to one direction in one area while the liquid crystal is made to arise and lie down to the other direction in the other area, thereby forming the areas with different viewing angle characteristics within a single pixel. When observing as a whole, the viewing angle characteristics are leveled and larger viewing angle is obtained.

[0004]

In order to control the alignment of the liquid crystal, rubbing is usually performed on the alignment film. When domain dividing is performed, the one area of the single pixel is rubbed in a first direction by using a mask and the other area of the single pixel is rubbed in a second direction which is the opposite direction from the first direction by using a complementary mask. As another way, the whole alignment film may be rubbed in the first direction and ultraviolet irradiation is selectively performed in one area or in the other area of the single pixel by using the mask, thereby creating a difference in pre-tilt in the liquid crystal between in one area and the other area.

[0005]

Since the liquid crystal display using the horizontal alignment film requires to perform rubbing, and requires to clean the substrate with the alignment film after performing rubbing. Therefore, the fabrication method of the liquid crystal panel is comparatively troublesome and there is a possibility to generate the contamination during the rubbing process.

[0006]

On the other hand, in a VA (Vertically Aligned) mode liquid crystal display using the vertical alignment film, when no voltage is applied, the liquid crystal is aligned substantially perpendicular to the vertical alignment film and when voltage is applied, the liquid crystal lies down substantially in the horizontal direction to the vertical alignment film. In this way, high contrast is obtained and the low contrast, which is the second disadvantage of the TN mode liquid crystal display above, is eliminated. However, rubbing is also normally performed on the alignment film to control the alignment of the liquid crystal in the general VA mode liquid crystal display using the vertical alignment film.

[0007]

The Japanese Patent Application No. 10-185836 by the applicant of this application proposes a liquid crystal display which can control the alignment of the liquid crystal without rubbing. This liquid crystal display is a VA mode liquid crystal display having the vertical alignment film and the liquid crystal with negative dielectric anisotropy and has a linear structure (a protrusion or a slit) arranged on each of the pair of substrates in order to control the alignment of the liquid crystal.

[0008]

It will be noted, hereinafter, the VA mode liquid crystal display according to this method is referred to as an MVA (Multi-domain Vertical Alignment) liquid crystal display in this application.

[0009]

This MVA liquid crystal display has an advantage that rubbing is not required and, further, the domain dividing is achieved by the arrangement of the linear structure. Therefore, this MVA liquid crystal display can obtain the wide viewing angle and high contrast. Since rubbing is not required, a fabrication of the liquid crystal display is simple, the contamination due to shavings the alignment film during the rubbing process is eliminated, and reliability of the liquid crystal display is improved.

[0010]

Fig. 8 is a diagram of a basic structure of the MVA liquid crystal display, showing a single pixel and its periphery. Further, throughout all the diagrams, items assigned the same reference code indicate the same thing and its repeated description is omitted.

[0011]

An MVA liquid crystal display 130 is an active matrix type liquid crystal display having a thin film transistor (hereinafter, referred to as a TFT) 14 at each pixel as a switching device, and there are a red pixel R, a green pixel G and a blue pixel B in the pixel to perform the color display.

[0012]

On a TFT substrate where the TFT 14 is provided, a gate bus

line 10 partially serving also as a gate electrode of the TFT 14 and a drain bus line 12 are formed. The TFT 14 consists of a drain electrode 12D extending from the drain bus line 12, a source electrode 12S positioned facing the drain electrode 12D, and an overlapping portion between the drain electrode 12D and the source electrode 12S of the gate bus line 10. Further, a pixel electrode 16 connected to the source electrode 12S is formed on the TFT substrate. In the pixel electrode 16, a slit 18 is provided diagonally to the pixel and this slit 18 becomes a structure to control the alignment of the liquid crystal on the TFT substrate side. A connecting portion 16a is provided at the pixel electrode 16 so that the pixel electrode 16 is not electrically separated by the slit 18. In this way, a pixel electrode in a pixel is electrically connected.

[0013]

Although not shown, on a color filter substrate (hereinafter, referred to as a CF substrate) where a color filter is formed, a protrusion 20 to be a structure to control the alignment of the liquid crystal on the CF substrate side is formed and controls the alignment of the liquid crystal together with the slit 18 on the TFT substrate.

[0014]

For example, when a diagonal distance of an XGA LCD (liquid crystal display) panel is equal to 15 inches, the size of a single pixel is equal to 99 μm X 297 μm, the widths of the slit 18 and the protrusion 20 are equal to 10 μm each, the distance between the slit 18 and the protrusion 20 when viewed planely is 25 μm. Further, the width of the connecting portion 16a of the pixel electrode 16 is equal to 4 μm and the distance between an end

portion of th drain bus line 12 and an end portion of the pixel electrode 16 is equal to 7 μm.

[0015]

Fig. 9 is simplified cross sectional views at a line I-I in Fig. 8 and shows actions of the slit 18 and the protrusion 20 which are the structures to control the alignment of the liquid crystal.

[0016]

Fig. 9(a) shows a state of the liquid crystal when no voltage is applied between the electrodes on a pair of substrates. The pixel electrode 16 is formed on a glass electrode 24 on the TFT substrate side, and the slit 18 is formed on the pixel electrode 16. Further, an alignment film (vertical alignment film) 32 is formed covering the pixel electrode 16 and the slit 18. On the other hand, a common electrode 26 is formed on a whole surface of a glass substrate 22 on the CF substrate side, facing the pixel electrode 16, and the protrusion made of an insulator (a dielectric) such as photo resist is formed on the common electrode 26. Further, an alignment film (vertical alignment film) 28 is formed covering the common electrode 26 and the protrusion 20.

[0017]

Furthermore, a liquid crystal layer LC is in between the TFT substrate and the CF substrate, and liquid crystal molecules (indicated by ellipses in the diagram) are aligned perpendicular to the alignment films 32 and 28. Therefore, the liquid crystal molecules are also aligned perpendicular to the alignment film 28 formed on the surface of the protrusion 20, and the liquid crystal molecules adjacent to the surface of the protrusion 20 are in an inclined state against the glass substrate 22. However, when closely observed, the liquid crystal molecules adjacent to the

surface of the protrusion 20 are not aligned perpendicular to the alignment film 28, because the liquid crystal molecules are aligned substantially perpendicular to the glass substrate 22 by the alignment film 28 in an area where the protrusion 20 is not formed and due to the continuum characteristics of the liquid crystal, the liquid crystal molecules follow the liquid crystal molecules occupying a most portion in the pixel and are in a state inclined from the direction perpendicular to the alignment film 28 to the direction of a normal line of the glass substrate. Also, although not shown, a pair of polarizing plates are arranged on the outside of the glass substrates 22 and 24 in the state of cross-Nicol. Therefore, in a state no voltage is applied, display becomes a black display.

[0018]

Fig. 9(b) shows equipotential lines when voltage is applied between the electrodes on a pair of substrates and Fig. 9(c) shows the state of the liquid crystal in the case above. As shown by equipotential lines shown by dotted equipotential lines in Fig. 9(b), when voltage is applied between the electrodes 16 and 26, distribution of an electric field in the portion where the slit 18 and the protrusion 20 are formed becomes different from the other portion. This is because in the portion where the slit 18 is formed, an oblique electric field is formed from the end portion of the electrode toward the opposing electrode, and in the portion where the protrusion 20 is formed, the electric field is distorted, since the protrusion 20 is a dielectric provided on the electrode 26. Therefore, as shown in Fig. 9(c), the liquid crystal molecules lie toward the direction of the arrow in the diagram. In other words, the liquid crystal molecules lie toward the dir ction

perpendicular to the direction of the electric field depending on the magnitude of the voltage, thereby providing a white display in a state when voltage is applied. At this time, when the protrusion 20 is arranged linearly as shown in Fig. 8, the liquid crystal molecules adjacent to the protrusion 20, having the protrusion 20 as the boundary, lie to two substantially perpendicular directions to the direction where the protrusion 20 is arranged. Since the liquid crystal molecules adjacent to the protrusion 20 are slightly inclined toward the perpendicular direction to the substrate even when no voltage is applied, the liquid crystal molecules adjacent to the protrusion 20 quickly respond to the electric field and lie down, followed by surrounding liquid crystal molecules which lie down quickly further being influenced by the electric field. In the similar manner, when the protrusion 18 is provided linearly as shown in Fig. 8, the liquid crystal molecules adjacent to the slit 18, having the slit 18 as a boundary, also lie to two substantially perpendicular directions to the direction where the slit 18 is arranged.

[0019]

Thus, in the area between the alternate long and short dash line in Fig. 9(a), the liquid crystal molecules fall down to the same direction. In other words, the area aligned in the same direction is formed. This area is indicated by [A] in Fig. 8. As shown representatively by [A] through [D] in Fig. 8, since areas aligned to four different directions are formed in a single pixel, in the MVA liquid crystal display 130, characteristics of wide viewing angle can be obtained. It will be noted that the alignment control like this can be not only performed when the slit 18 and the protrusion 20 are combined as shown in Figs. 8 and 9 but also

the same alignment control can be performed when a protrusion and a protrusion or a slit and a slit, as a structure to control the alignment, are combined.

[0020]

However, although wide viewing angle can be obtained in the MVA liquid crystal display 130, an area liquid crystal molecules are not stable exists, and therefore, the problem of reduction in brightness exists. In other words, when voltage is applied between the electrodes, an alignment defect area 40 shown by hatching in Fig. 8 occurs. Since this alignment defect area 40 is an area the transmissivity of the light is poor, the alignment defect area results in a reduction in brightness when the white display is performed. When viewed planely, this alignment defect area 40 occurs on the side where the structures (protrusion or slit) provided on the CF substrate form an obtuse angle with an edge portion of the pixel electrode 16. This cause of occurrence of the alignment defect area 40 is caused by a lateral electric field and the like generated by an influence of the drain bus line 12 at the edge portion of the pixel electrode 16. In the area this alignment defect area 40 occurs, the liquid crystal molecules lie in the different alignment direction from the alignment direction controlled by the structures (the slit 18 and the protrusion 20 in Fig. 8) provided on a pair of substrates. In other words, the alignment of the liquid crystal molecules is disturbed in this area due to the occurrence of the lateral electric field and the like, thereby resulting in a deterioration in display characteristic of the MVA liquid crystal display 130.

[0021]

[Problems to be Solved by the Invention]

In order to solve a problem (occurrence of an alignment defect area) characteristic to this MVA liquid crystal display, the applicant of this application proposes a new structure to reduce influences from a lateral electric field and the like.

[0022]

Fig. 10 shows an MVA liquid crystal display 140 according to the proposal. A distinctive feature of this structure is that an auxiliary protrusion 20c extending from the protrusion 20 provided in the CF substrate side along an end portion of the pixel electrode 16 where the alignment defect area 40 occurs is provided. The auxiliary protrusion 20c can certainly be formed by the same material and the same process as the protrusion 20 or can be formed separately.

[0023]

Fig. 11 is a diagram describing the auxiliary protrusion 20c to be formed on the CF substrate. As a structure of the CF substrate, as shown in Fig. 11(a), a method to form a black matrix BM to be formed on the CF substrate by overlaying color resins forming a color filter is proposed. This method is achieved by forming red resin R, green resin G and blue resin B on the glass substrate 22, and overlapping, as blue resin B with green resin G, blue resin B with red resin R and red resin R with green resin G, at each end portion. The overlapped portion is the black matrix BM. Then, the common electrode 26 and the like are formed above.

[0024]

In the case of the CF substrate formed by such a method (hereinafter, referred to as a resin overlaying BM method), a level difference equal to approximately 0.2 - 1.5 μm occurs at portions indicated by circles in Fig. 11(a), in other words, at the portions

color resins are overlapped. If there is the level difference like this, an electric line of force concentrates at the portions, thereby causing alignment defects of liquid crystal molecules.

[0025]

Fig. 11(b) shows a state when the auxiliary protrusion 20c is formed at the portion of the level difference of the black matrix. The auxiliary protrusion 20c is formed to cover the portion where there is the level difference. In such a state, the height d1 of the level difference is equal to approximately 0.2 - 1.5 μm as described above, and the height from the peak portion of the auxiliary protrusion 20c is equal to approximately 1.0 - 2.0 μm. The auxiliary protrusion 20c functions to atably align the liquid crystal molecules by easing the inclination at the portion where there is the level difference and not to concentrate the electric line of force by forming a material with low dielectric constant at the portion where there is the level difference at an angular portion. For example, a relative dielectric constant ε of the liquid crystal is approximately 6 - 8 and the relative dielectric constant ε of the protrusion material is approximately 3 - 4.

[0026]

However, in the portions designated by the circles in Fig. 11(b), there is a case when the auxiliary protrusion 20c does not sufficiently cover angular portion of level difference due to irregularities of level difference, irregularities of locations forming the protrusion, irregularities of the protrusion shape and the like.

[0027]

Figs. 12 and 13 are diagrams showing the problems in the past. In Fig. 12(a), a case when the auxiliary protrusion 20c is provided

on the CF substrate of the resin overlaying BM method is shown. Fig. 12(a) shows a cross section at a line I-I in Fig. 10. On the TFT substrate, the drain bus line 12 is formed on the glass substrate 24, the drain bus line 12 is covered with an insulation film 30, and the pixel electrode is further formed on the insulation film 30. The insulation film 30 consists of a TFT gate insulation film, a protection film covering the TFT and the like. Hitherto, the width d1 of the auxiliary protrusion 20c is equal to approximately 10 μm, the width d2 where the auxiliary protrusion 20c and the pixel electrode 16 overlap is designed to be approximately 4 μm.

[0028]

However, if the auxiliary protrusion 20c is formed on the CF substrate of the resin overlaying BM method with this design value, the thickness of the protrusion material becomes thin at the angular portion of a color resin, for example, in the angular portion of the green resin G. Since the common electrode 26 is formed on the surface of the green resin G of the angular portion, the electric line of force heading outwards from the display area concentrates, and the liquid crystal molecules become a state of alignment defect due to the electric field in this portion. Since the area of the alignment defect enters inside the display domain, the similar dark portion as the alignment defect area 40 in Fig. 8 is formed.

[0029]

Further, besides the resin overlaying BM method described above, there is a method using a black resin as the black matrix (hereinafter, referred to as a resin BM method). According to this resin BM method, the black resin is placed in the area forming the

black matrix and each resin is formed in an opening portion (display domain) so that the end portion of each resin overlaps the black resin. Therefore, as is the case in the resin overlaying BM method, the level difference is formed and the similar problem described above occurs.

[0030]

Fig. 12(b) shows a case when other color filter shape is applied on the CF substrate, in which a chrome shading film 34 is formed as the black matrix and the color filter is formed on the shading film 34 by patterning the color resin. In this case, the width d1 of the auxiliary protrusion 20c is also equal to approximately 10 μm and the width d2 where the auxiliary protrusion 20c and the pixel electrode 16 overlap is also designed to be approximately 4 μm. As shown in Fig. 12(b), when formed according to the design value, the concentration of electric line of forc heading outwards from the display area is suppressed, the alignment of the liquid crystal molecules is stabilized and the display becomes favorable. However, at the stage when a product is actually fabricated, various irregularities during the fabrication occur, and in many cases, desired characteristics are not obtained.

[0031]

Fig. 13 is a diagram showing problems of misalignment in lamination and shot unevenness as irregularities during the fabrication. Fig. 13(a) shows a case in which a misalignment occurs when the CF substrate and the TFT substrate are laminated, and the width d1 of the auxiliary protrusion 20c is equal to approximately 10 μm as is the case in Fig. 12(b). However, in Fig. 13(a), the TFT substrate is deviated in an upper right direction

to the CF substrate in the diagram, thereby resulting in the width d2 where the auxiliary protrusion 20c and the pixel electrode 16 overlap by approximately 3 μm. Therefore, the control power to the liquid crystal molecules is weakened, and an influence from the lateral electric field caused by the drain bus line at the end portion of the pixel electrode 16 occurs, therefore the alignment defect area as indicated by the hatched portion in the diagram occurs. However, in the case of Fig. 13(a), the alignment defect area is under the auxiliary protrusion 20c and does not affect the display. It will be noted that when a misalignment in lamination occurs, the opposing width becomes wider at one end portion of the corresponding pixel electrode and the width becomes narrow at the other end portion. That is, in order to have a sufficient opposing width at the corresponding end portions, a margin for laminating extremely reduces and fabrication also becomes difficult.

[0032]

At this time, as shown in Fig. 13(c), exposure and the like are performed by dividing the display domain of a single panel into a plurality of divided areas SA ~ SD ... when fabricating the liquid crystal display (liquid crystal panel). Therefore, the same display characteristics can be obtained within each divided area SA ~ SD .... However, when there are deviations or the like during exposure, display characteristics may be different from other divided areas.

[0033]

Fig. 13(b) shows other divided area in the same panel as Fig. 13(a) and shows a case when shot irregularities occur during exposure. In Fig. 13(b), since irregularities occur when patterning the pixel electrode 16, although the distance d3 from

the end face of the color resin B to the end face of the pixel electrode 16 is supposed to be equal to 7 μm according to the original design value as shown in Fig. 13(a), the distance d5 in Fig. 13(b) is equal to 7.5 μm. Therefore, the width d4 where the auxiliary protrusion 20c and the pixel electrode 16 overlap becomes to be equal to 2.5 μm and the alignment defect area indicated by the hatched portion occurs in the diagram. Furthermore, the alignment defect area appears in the display domain instead of being hidden by the auxiliary protrusion 20c. Therefore, in Fig. 13(b), the alignment defect area 40 as shown in Fig. 8 occurs in the display domain.

[0034]

In Fig. 13(c), if the divided area SA is an area where the pixel electrode 16 is formed in the position in accordance with the design standard as shown in Fig. 13(a) and the divided area SB is an area where the position of the pixel electrode 16 is deviated from the predetermined position due to shot irregularities as shown in Fig. 13(b), although a desired bright display is performed in the divided area SA when a certain display is performed, the alignment defect area occurs in the divided area SB, thereby resulting in a dark display. In other words, an irregular shot phenomenon occurs.

[0035]

Fig. 14 is a diagram showing the relationship between the design value of the overlapping width (opposing width) and the generation ratio of shot irregularities in which the overlapping width between the auxiliary protrusion and the pixel electrode. Here, an attention should be paid that the design value of the overlapping width on the lateral axis is not the overlapping width

inside the actual panel. Even if the panel is fabricated according to a certain design value, irregularities of several μm due to a misalignment of lamination between an upper and lower substrates, inaccuracy of the pattern for the structure (protrusion, color resin for color filter, etc.) formed on the substrate or the influence from the divided areas described above occur inside the actually fabricated panel. Therefore, the value of the overlapping width, when the whole display domain is viewed, is in a certain range. In this case, the alignment defect area appears inside the display domain in the portion where the overlapping width is small and the difference in brightness partially occurs in the whole display domain. In such a case, shot irregularities are considered to have occurred at the design value.

[0036]

When observing like this, if the design value of the overlapping width, in other words, if the design center is equal to approximately 4 μm, the irregularity in shooting occurs at a ration of substantially 50 %. The range of the values for the actual overlapping widths in this case is considered to vary from approximately 1 μm to 7 μm. If the design center is equal to approximately 6 μm, the shot irregularities are almost eliminated. The overlapping width in this case is considered to vary from approximately 3 μm to 9 μm.

[0037]

Thus, in the MVA liquid crystal display in the past, as is the case using the color filter of the resin overlaying BM method or the resin BM method, a problem that many display defects in which brightness reduces occurs when there is a large level difference on the substrate. Further, there is a probl m that poor yield

caused by extremely small margin in fabrication exists as is the case because a display defect is easily caused by slight irregularities in fabrication.

[0038]

Therefore, an object of the present invention is to provide a liquid crystal display which is high in brightness and has preferable display characteristics and its fabrication method.

[0039]

Another object of the present invention is to provide a liquid crystal display with large margin in fabrication, high yield, and preferable display characteristics and its fabrication method.

[0040]

[Means for Solving the Problem]

According to the first aspect of the present invention, the above subjects can be solved by a liquid crystal display having the following distinctive feature.

[0041]

That is to say, a liquid crystal display comprises a first substrate having a first electrode, a second substrate having a second electrode corresponding to a pixel, a liquid crystal having negative dielectric anisotropy sealed between the first and the second substrates, a structure which is provided on each of the first and the second substrates to control an alignment of the liquid crystal, and wherein the structure on the first substrate has a linear protrusion structure, at least two auxiliary protrusion structures extending from the protrusion structure and opposing to each of facing end portions of the second electrode, and a width of the two auxiliary protrusion structures facing the

second electrode is 6 μm or more.

[0042]

According to the first aspect of the present invention, since the width of the auxiliary protrusion facing the second electrode is 6 μm or more at each corresponding end portion of the second electrode, an alignment defect area does not appear inside the display domain and a bright and preferable display with no reduction in brightness is possible.

[0043]

Further, according to the second aspect of the present invention, the above subjects can be solved by a liquid crystal display having the following distinctive feature.

[0044]

That is to say, a liquid crystal display comprises a first substrate having a first electrode, a second substrate having a second electrode corresponding to a pixel, a liquid crystal having negative dielectric anisotropy sealed between the first and the second substrates, a structure arranged on each of the first and the second substrates to control an alignment of the liquid crystal, and wherein the structure on the first substrate has a linear protrusion structure arranged diagonally to the pixel, and at least a part of end portions of the second electrode being in the area decided by the protrusion structure and the structure on the second substrate and forming an obtuse angle with the protrusion structure extends outside.

[0045]

According to the second aspect of the present invention, at least in the area where the alignment defect occurs easily, since the second electrode extends outside of the display domain,

occurrence of an alignment defect area can be suppressed. Further, even if the alignment defect area is formed, an alignment defect area appearing in the display domain can be suppressed, and a bright and preferable display with no reduction in brightness is possible.

[0046]

[Modes of Carrying out the Invention]

Embodiments of the present invention are described below with reference to diagrams.

[0047]

Fig. 1 shows a first embodiment of the present invention and is according to the first aspect of the present invention.

[0048]

With reference to Fig. 1, a MVA liquid crystal display 100 is an active matrix type liquid crystal display provided with a switching device and a thin film transistor (hereinafter, referred to as a TFT) 14 at each pixel and there are a red pixel R, a green pixel G and a blue pixel B as the pixels so that color display can be performed. Fig. 1 shows one of the pixels and its peripheral portion.

[0049]

On a TFT substrate where a TFT 14 is provided, wirings of a gate bus line 10 partially serving as a gate electrode for the TFT 14 and a drain bus line 12 are formed. The TFT 14 comprises a drain electrode 12D extending from a drain bus line 12, a source electrode 12S placed opposing to the drain electrode 12D, and a part of the gate bus line 10 overlapping the drain electrode 12D and the source electrode 12S. Further, a pixel electrode 16 connected to the source electrode 12S is formed on the TFT

substrate. In the pixel electrode 16, a slit 18 is provided diagonally to the pixel in the diagram and this slit 18 becomes a structure which controls the alignment of the liquid crystal on the TFT substrate side. A connecting portion 16a is provided at the pixel electrode 16 so that the pixel electrode 16 is not electrically separated by the slit 18. In this manner, a pixel electrode in a single pixel is electrically connected.

[0050]

On a CF substrate where a color filter not shown is formed, a protrusion 20 which is to be a structure to control the alignment of the liquid crystal on the CF substrate side is provided diagonally to the pixel, and controls the alignment of the liquid crystal along with the slit 18 on the TFT substrate. The slit 18 and the protrusion 20 are placed alternately when viewed planely. Further, an auxiliary protrusion 20a is formed to extend out of the protrusion 20 along the end portion of the pixel electrode 16. The auxiliary protrusion 20a is formed by extending out of the protrusion 20 at a side, where the protrusion 20 and a pixel electrode 20a form an obtuse angle, at the part where the protrusion 20 intersects the pixel electrode 16 when viewed planely.

[0051]

For example, when the MVA liquid crystal display 100 is an XGA LCD panel which has a diagonal distance of 15 inches, the size of a single pixel is equal to 99 μm X 297 μm, the widths of the slit 18 and the protrusion 20 are equal to 10 μm respectively, and the distance between the slit 18 and the protrusion 20 when viewed planely is equal to 25 μm. Further, the width of the connecting portion 16a of the pixel electrode 16 is equal to 4 μm and the

distance between the end portion of the drain bus line 12 and the end portion of the pixel electrode 16 is equal to 7 μm.

[0052]

The point which makes the MVA liquid crystal display 100 shown in Fig. 1 different from an MVA liquid crystal display 140 shown in Fig. 10 is the arrangement of the auxiliary protrusion 20a. The auxiliary protrusion 20a of the MVA liquid crystal display 100 is formed by entering inside a display domain in comparison with an auxiliary protrusion 20c of the MVA liquid crystal display 140. Here, the display domain means an opening of the pixel and the area where a light actually transmits. Although not shown in Fig. 1, a black matrix is formed on the CF substrate having the protrusion 20 and the end face of the black matrix and the end face of the pixel electrode 16 are formed so that they substantially coincide with each other, and in Fig. 1, an borderline of the pixel electrode 16 (The borderline is a borderline on an assumption that the slit 18 does not exist. The same thing applies below.) becomes a visible outline of the display domain. In Fig. 1, all the auxiliary protrusions 20a are formed so that the width between the auxiliary protrusion 20a and the opposing pixel electrode 16 becomes equal to approximately 8 μm.

[0053]

Fig. 2(a) is a cross sectional view at a line I-I in Fig. 1 and shows an action according to the structure in Fig. 1. A resin overlaid BM type color filter is formed on the CF substrate, a blue resin B is formed on the glass substrate 22, and at the portion where the black matrix is formed, a green resin G is formed by overlaying on the blue resin B. Further, the end face of the green resin G, which is to be the end face of the black matrix,

substantially coincide with the end face of the pixel electrode 16 formed on a glass substrate 24. Thus, a portion where the pixel electrode 16 is formed (including a slit 18 portion) is the display domain.

[0054]

The width d1 of the auxiliary protrusion 20a is equal to approximately 10 μm and the opposing width d2 between the auxiliary protrusion 20a and the pixel electrode 16 is equal to 8 μm. Further, since the auxiliary protrusion 20a is formed sufficiently inside (display domain side) in order to avoid an influence from an angular portion of the green pixel G, concentration of an electric line of force toward an angular portion of color resin can be avoided and an alignment defect area does not appear in the display domain. Therefore, a light and good display with a high brightness can be obtained.

[0055]

Fig. 3 shows a second embodiment of the present invention and is according to the second aspect of the present invention.

[0056]

With reference to Fig. 3, the points which make an MVA liquid crystal display 110 different from the MVA liquid crystal display 100 in Fig. 1 are the position of an auxiliary protrusion 20b and the shape of the pixel electrode 16 at the opposing portion to the auxiliary protrusion 20b.

[0057]

In the MVA liquid crystal display 110, the auxiliary protrusion 20b is formed at the borderline of the pixel electrode 16, in other words, 6 μm inside the visible outline of the display domain. Further, an overhanging portion 16c extending beyond the

borderline of the pixel electrode 16 is formed at a portion where the pixel electrode 16 faces the auxiliary protrusion 20b. The overhanging amount m of the overhanging portion 16c becomes equal to 2 μm. Therefore, an opposing width n between the auxiliary protrusion 20b and the pixel electrode 16 becomes equal to 8 μm which provides a sufficient opposing width. Compared with the first embodiment, although the opposing widths are the same and equal to 8 μm, the auxiliary protrusion 20b does not enter the display domain, thereby reducing an occupied area of the auxiliary protrusion 20b at the display domain and increasing an aperture ratio more. This contributes to an increase in brightness.

[0058]

Further, a slit is composed of a collection of short slits 18' in the MVA liquid crystal display 110. A connecting portion 16b of the pixel electrode 16 is formed between the slits 18'. A structure to control the alignment is thus formed by a plurality of unit structures to stabilize the alignment of liquid crystal molecules on the structure, and to create a higher brightness and a quick response time can be improved.

[0059]

Fig. 2(b) is a cross sectional view at a line I-I in Fig. 3 and shows an action according to the structure in Fig. 3. A color filter using a chrome shading film as the black matrix is formed on the CF substrate. The width d1 of the auxiliary protrusion 20b and the opposing width d2 between the auxiliary protrusion 20b and the pixel electrode 16 are equal to 10 μm and 8 μm respectively as is the case of the first embodiment. However, since the pixel electrode 16 has the overhanging portion 16c extending beyond the display domain, the width of the auxiliary protrusion 20b ent ring

the display domain is reduced.

[0060]

With reference to Fig. 4 which is a cross sectional view at a line II-II in Fig. 1, a detailed description follows. Although not shown, a gate electrode made of aluminum and the like is formed on the glass substrate 24 on the TFT substrate side, and a gate insulation film 36 is formed approximately to 4000 Å in thickness on the gate electrode. A drain bus line 12 is formed approximately to 1500 - 3500 Å in thickness on the gate insulation film 36 and a protection film 30 covering the TFT is formed approximately to 3300 Å in thickness on the drain bus line 12. An ITO (indium tin oxide) which is to be the pixel electrode 16 is formed approximately to 500 - 1500 Å in thickness on the protection film 30 and an alignment film 32 covering the protection film 30 and the pixel electrode 16 is formed approximately to 300 - 1200 Å in thickness.

[0061]

Further, a chrome shading film 34 is formed to approximately 1000 - 2000 Å in thickness on the glass substrate 22 on the CF substrate side and color resins R, G and B are formed to approximately 0.9 - 2.5 μm each in thickness. The ITO which is to be a common electrode 26 is formed to approximately 500 - 1500 Å in thickness on the color resins R, G and B, and an alignment film 28 is formed to approximately 300 - 1200 Å in thickness on the ITO. It will be noted that the protrusion 20 and the auxiliary protrusion 20 are formed on the common electrode 26, covered by the alignment film 28, and have the height of approximately 1.2 - 1.8 μm.

[0062]

An end face of the pixel electrode 16 excluding the overhanging portion 16c of the pixel electrode 16 substantially coincides with an end face of the chrome shading film 34 and the distance d1 between the drain bus line 12 and the pixel electrode 16 is equal to 7 μm. Further, the overhanging portion 16c of the pixel electrode 16 extends 2 μm out of the display domain. Therefore, the distance d2 between the drain bus line 12 and the overhanging portion 16c is equal to 5 μm and the overlapping width d3 with the chrome shading film 34 is also 2 μm. Furthermore, the width of the auxiliary protrusion 20b overhanging on the display domain is equal to 6 μm and as a consequence, an opposing width between the auxiliary protrusion 20b and the pixel electrode 16 is 8 μm. So, the width of the auxiliary protrusion 20b entering the display domain is reduced as well as light and good display with a high brightness can be obtained, thereby improving the aperture ratio.

[0063]

It will be noted that if the width of the overhanging portion 16c is made larger, the auxiliary protrusion 20b on the CF substrate side is not required to be formed. That is because since an alignment defect area occurs slightly inside the end portion of the pixel electrode 16, when the extending width becomes larger, even if the alignment defect area occurs, the alignment defect area appearing in the display domain can be suppressed.

[0064]

Fig. 5 shows an example of a structure of the CF substrate and shows a technology in which a protrusion structure is overlaid on a resin overlaying BM method to serve also as a spacer (hereinafter, referred to as a spacerless CF). A CF substrate

using this spacerless CF can be applied to the first and the second embodiments and a third embodiment to be described below. In Fig. 5(a), hatching portions are portions each of color resin R, G and B is formed and functions as a color filter. Other portions are overlaid by color resins and function as the black matrix. The protrusion 20 is formed thereon. Fig. 5(b) is a cross sectional view at a line A-A' in Fig. 5(a). As shown in Fig. 5(b), two color resins are overlaid between each linear pixel to form the black matrix BM. Further, Fig. 5(c) is a cross sectional view at a line B-B' in Fig. 5(a). While portions other than lattice points become the black matrix BM by overlaying two color resins, three color resins are overlaid at the lattice points and furthermore, a protrusion 20c which is a part of the protrusion 20 is overlaid thereon and the protrusion 20c functions as the spacer.

[0065]

Fig. 6 is a third embodiment of the present invention and is according to the third aspect of the present invention.

[0066]

With reference to Fig. 6, the points which make an MVA liquid crystal display 120 different from the MVA liquid crystal display 110 in Fig. 3 are that an auxiliary protrusion is not formed and a shape of the pixel electrode 16 at a portion where an auxiliary protrusion is formed in the other embodiments.

[0067]

In the MVA liquid crystal display 120, the auxiliary protrusion is not formed. Instead, an overhanging portion 16d extending beyond the display domain and extending to above the drain bus line 12 which is the wiring is formed at the pixel electrode 16. The overhanging portion 16d is formed by extending

an end portion where the pixel electrode 16 and the protrusion 20 form an obtuse angle, beyond the display domain, in an area decided by the slit 18 arranged substantially in parallel and end portions of the protrusion 20 and the pixel electrode 16. In other words, the overhanging portion 16d is a pixel electrode portion adjacent to an area where the alignment defect area 40 occurs in the MVA liquid crystal display 130 in Fig. 8.

[0068]

With reference to Fig. 7 which is a cross sectional view at a line I-I in Fig. 6, a detailed description follows. First, in this embodiment, an auxiliary protrusion is not formed on the CF substrate side. On the TFT substrate side, a gate insulation film 36 is formed on the glass substrate 24 and the drain bus line 12 to be wiring is formed there. Further, a planarized film 38 which is made of acrylic resin and the like and serves also as a protecting film for the TFT is formed. The pixel electrode 16 and the alignment film 32 are formed on the planarized film 38. An end face of the pixel electrode 16 other than the overhanging portion 16d of the pixel electrode 16 substantially coincides with an end face of the chrome shading film 34. Furthermore, the overhanging portion 16d of the pixel electrode 16 extends 9 μm beyond the display domain (in other words, overlapping of 9 μm with the chrome shading film 34 exists), and overlapping of 2 μm with the drain bus line 12 via the planarized film 38 exists. By structuring in this manner, the end portion of the pixel electrode 16 can be arranged at a position sufficiently apart from the display domain. Also, since the thick planarized film 38 is between the overhanging portion 16d and the drain bus line 12, an influence from the drain bus line 12 can be reduced. Thus, even

if the alignment defect area occurs in adjacent to the end portion of the overhanging portion 16d, the alignment defect area occurs sufficiently apart from the display domain and does not affect the display. Hence, the light and good display with a high brightness can be obtained and since an arrangement of the auxiliary protrusion is not required, the aperture ratio can also be improved.

[0069]

It will be noted that, in this embodiment, the auxiliary protrusion may be formed on the CF substrate side. In that case, consideration may be given to a position to form the auxiliary protrusion so that an influence given to the aperture ratio is reduced.

[0070]

Although the present invention is described above in detail, the present invention is not limited to the above embodiments and can be deformed to an extent the present invention is not deviated.

[0071]

It will be noted that, in the present invention, the following structure may also be distinctive features:

[0072]

(1) A first substrate is the CF substrate and a first electrode is the common electrode.

[0073]

(2) A second substrate is the TFT substrate and a second electrode is the pixel electrode.

[0074]

(3) In the above structure (2), a structure of the second substrate is the slit to be formed in the pixel electrode.

[0075]

(4) A structure to control the alignment of the liquid crystal on the first and the second substrate is arranged in an inclined fashion against the pixel.

[0076]

(5) In the above structure (4), inclined directions against the pixel are at least two directions in a single pixel.

[0077]

(6) The width of the auxiliary protrusion is equal to approximately 10 μm and the opposing width is equal to approximately 8 μm.

[0078]

(7) The width of the second electrode extends is 2 μm or more.

[0079]

(8) In the above structure (1), a shape is formed by a level difference formed by overlaying resins and the auxiliary protrusion is formed at the portion of the level difference exists.

[0080]

(9) In the above structure (8), the black matrix is formed by overlaying color resins provided at each pixel.

[0081]

(10) In the above structure (8), a black resin to be the black matrix is provided and the end portion of color resins provided at each pixel is overlapped with the black resin.

[0082]

(11) In the above structure (8), the distance between an end face of the portion where the level difference exists and the end portion of the auxiliary protrusion is 6 μm or more.

[0083]

[Effect of the Invention]

As described in detail above, according to the present invention, a liquid crystal display becomes a preferable liquid crystal display which is high in brightness and has a light display characteristic because it is possible not to generate an alignment defect area or not to show the defect area in the display domain even if the defect area occurs.

[0084]

Further, the liquid crystal display is to have a high fabrication margin and high yield as well as preferable display characteristics, since the display is structured so that the alignment defect area occurs in the portion apart from the display domain even if the defect area occurs and the display defect due to a small deviation during the fabrication does not occur.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

It is a diagram showing a first embodiment of the present invention.

[Fig. 2]

It is a diagram showing an action of the present invention.

[Fig. 3]

It is a diagram showing a second embodiment of the present invention.

[Fig. 4]

It is a diagram showing a cross section at a line II-II in Fig. 3.

[Fig. 5]

It is a diagram showing a structure of a spacerless CF.

[Fig. 6]

It is a diagram showing a third embodiment of the present invention.

[Fig. 7]

It is a diagram showing a cross section at a line I-I in Fig. 6.

[Fig. 8]

It is a diagram showing a basic structure of an MVA liquid crystal display.

[Fig. 9]

It is a diagram showing a theory of the MVA liquid crystal display.

[Fig. 10]

It is a diagram showing the MVA liquid crystal display provided with an auxiliary protrusion in the past.

[Fig. 11]

It is a diagram showing an action of the auxiliary protrusion.

[Fig. 12]

It is a diagram (1) showing a problem point in the past.

[Fig. 13]

It is a diagram (2) showing a problem point in the past.

[Fig. 14]

It is a graph showing an occurrence rate of shot irregularities.

[Legend]

10 gate bus line

12 drain bus line

12D drain electrode

12S source electrode

14 thin film transistor (TFT)

16 pixel electrode

16a, 16b connecting portion

16c, 16d overhanging portion

18, 18′ slit

20 protrusion

20a, 20b, 20c auxiliary protrusion

22 glass substrate (CF substrate side)

24 glass substrate (TFT substrate side)

26 common electrode

28 alignment film (CF substrate side)

30 insulation film (protection film)

32 alignment film (TFT substrate side)

34 chrome shading film (black matrix)

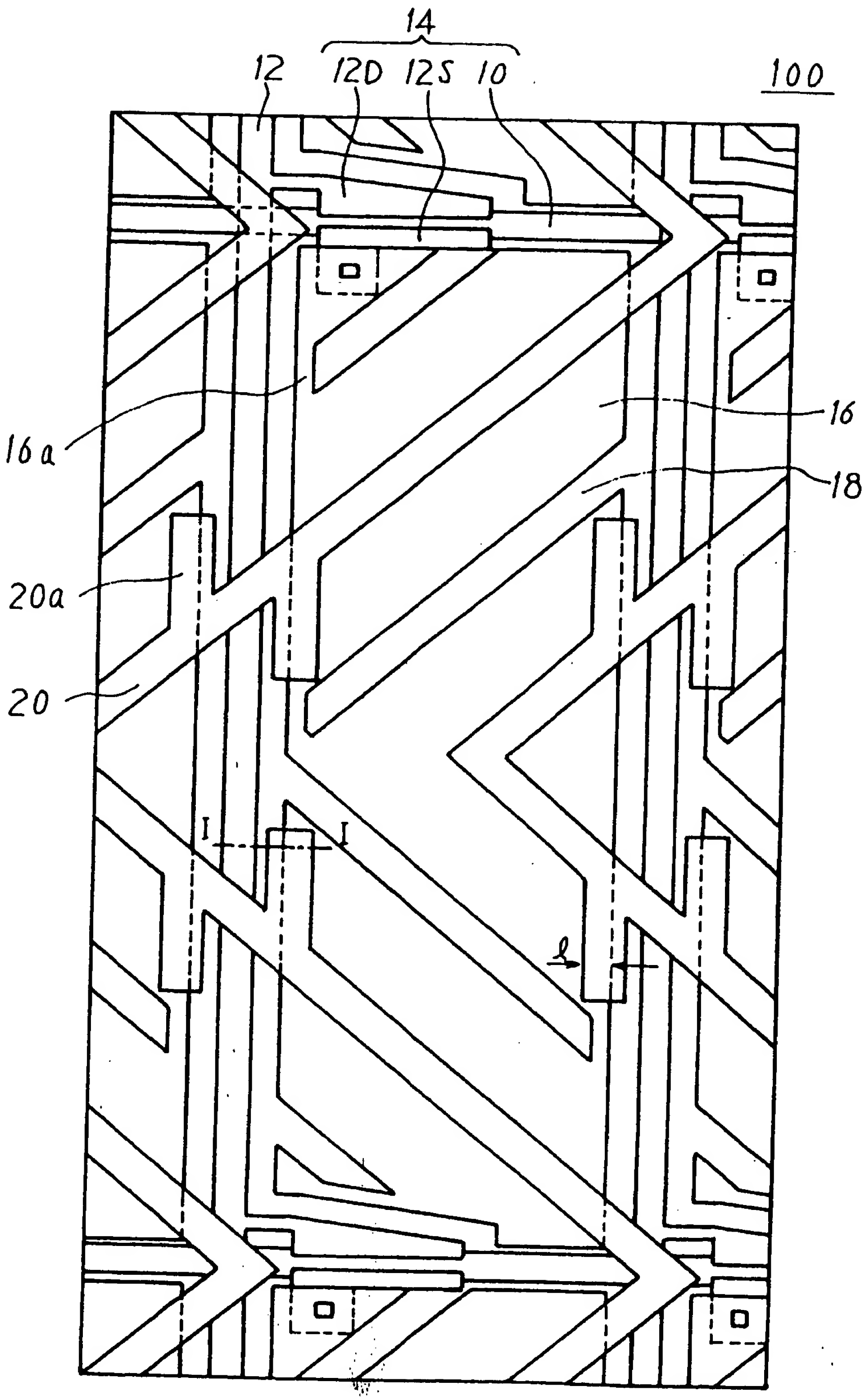
36 gate insulation film

38 planarized film

40 alignment defect area

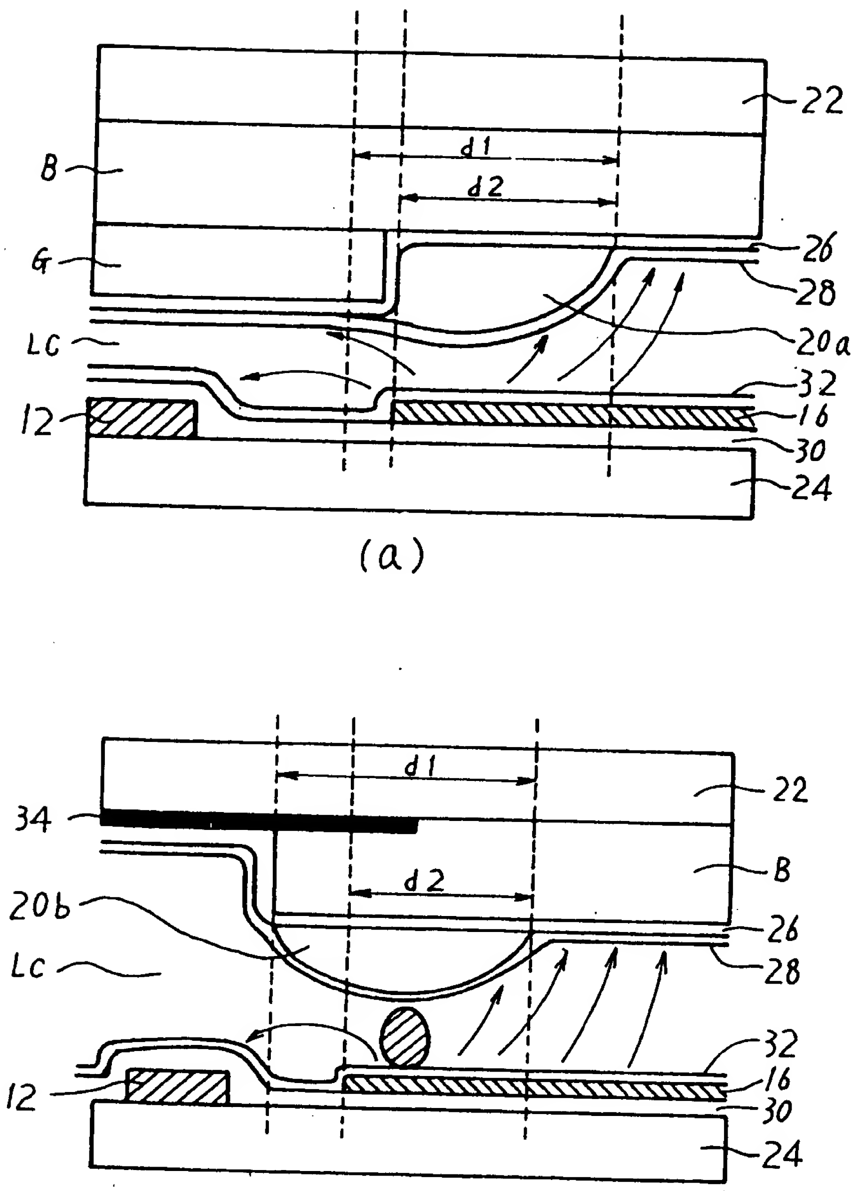
BM black matrix

FIG. 1



Certificate No. 2000-3006762

FIG. 2



(a)

(b)

FIG. 3

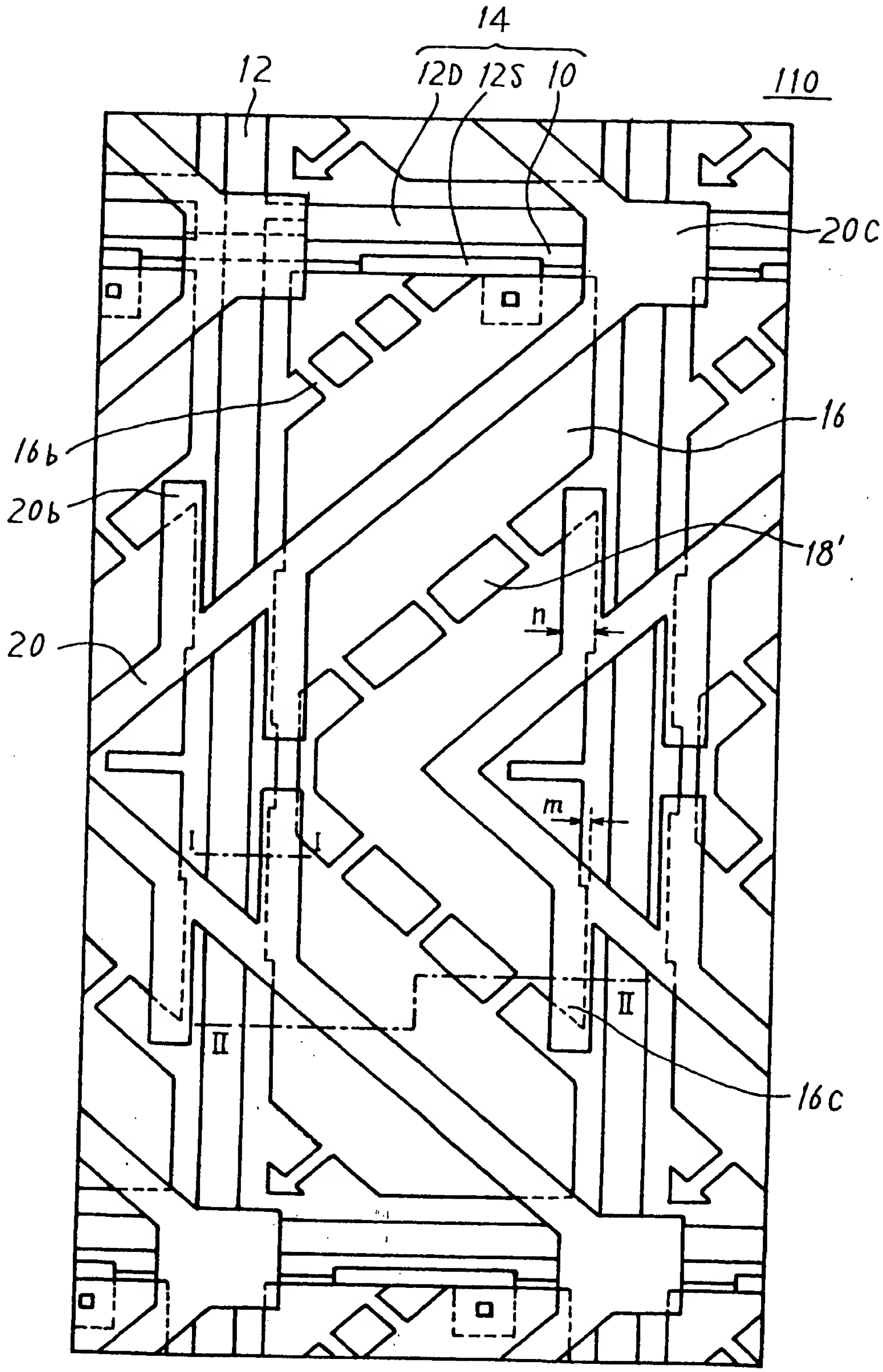
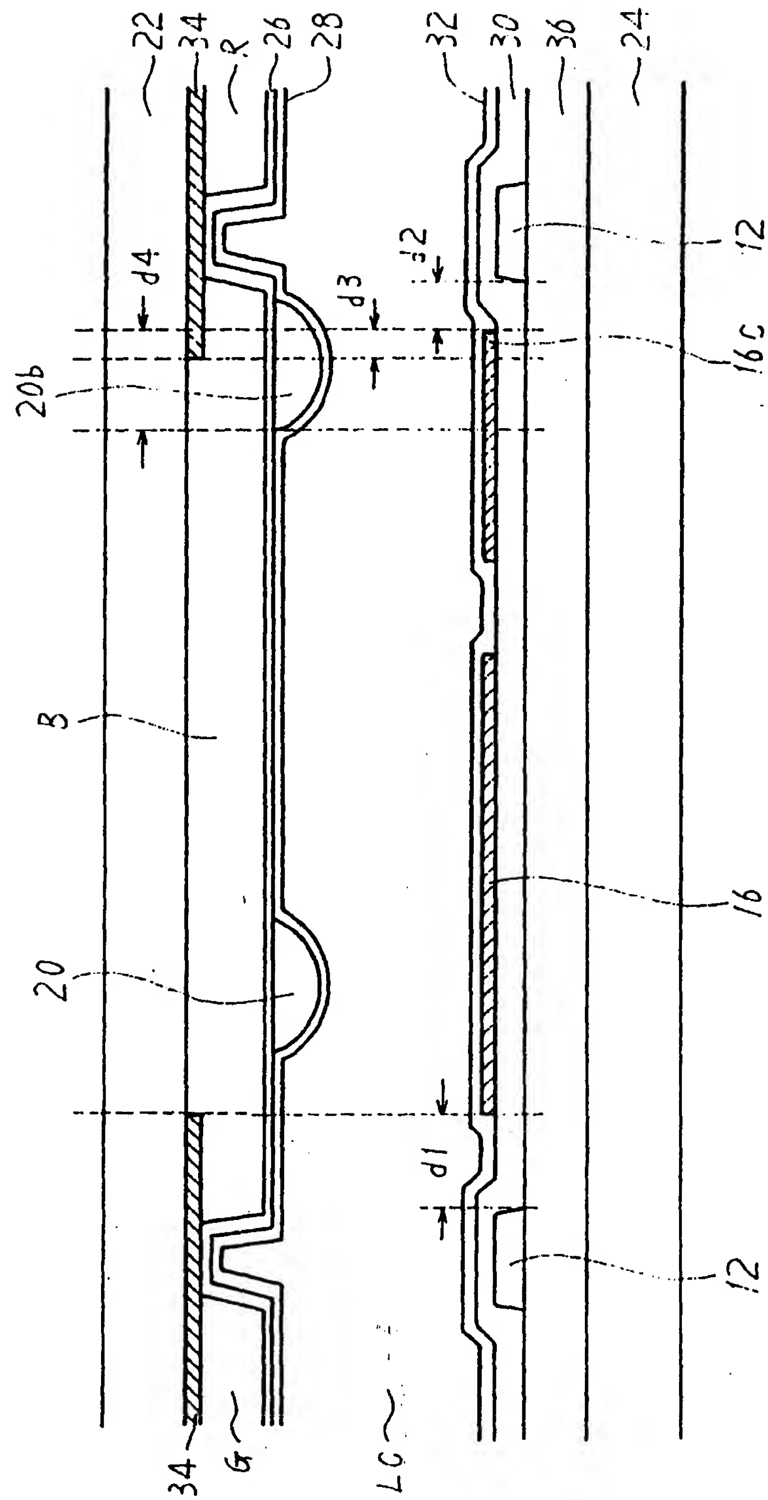
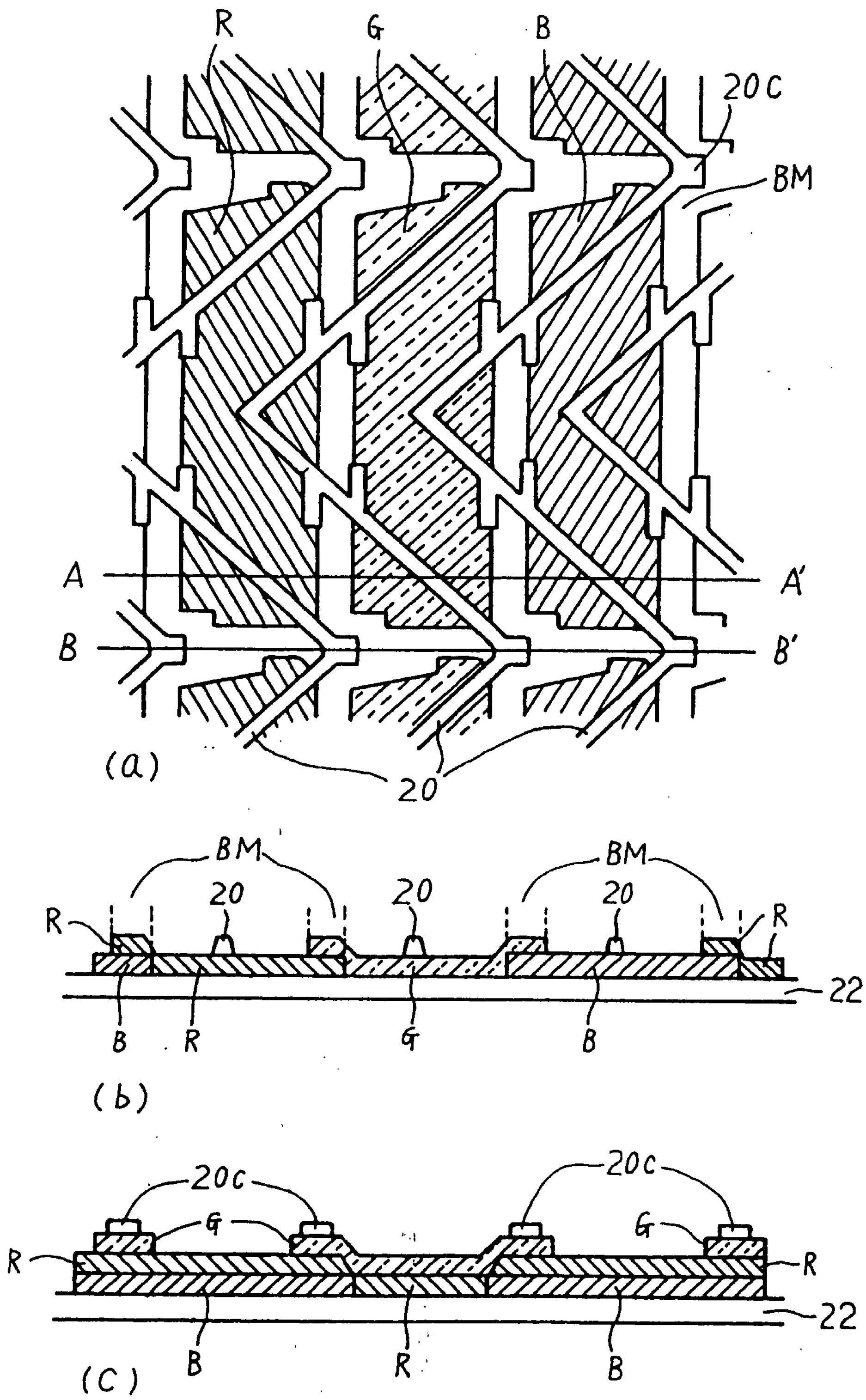


FIG. 4



F I G. 5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G
B
20C
BM
A
A'
B
B'
(a)
20
BM
BM
20
20
20
R
R
B
R
G
B
22
(b)
20c
20c
G
G
R
R
B
R
B
22
(C)

FIG. 6

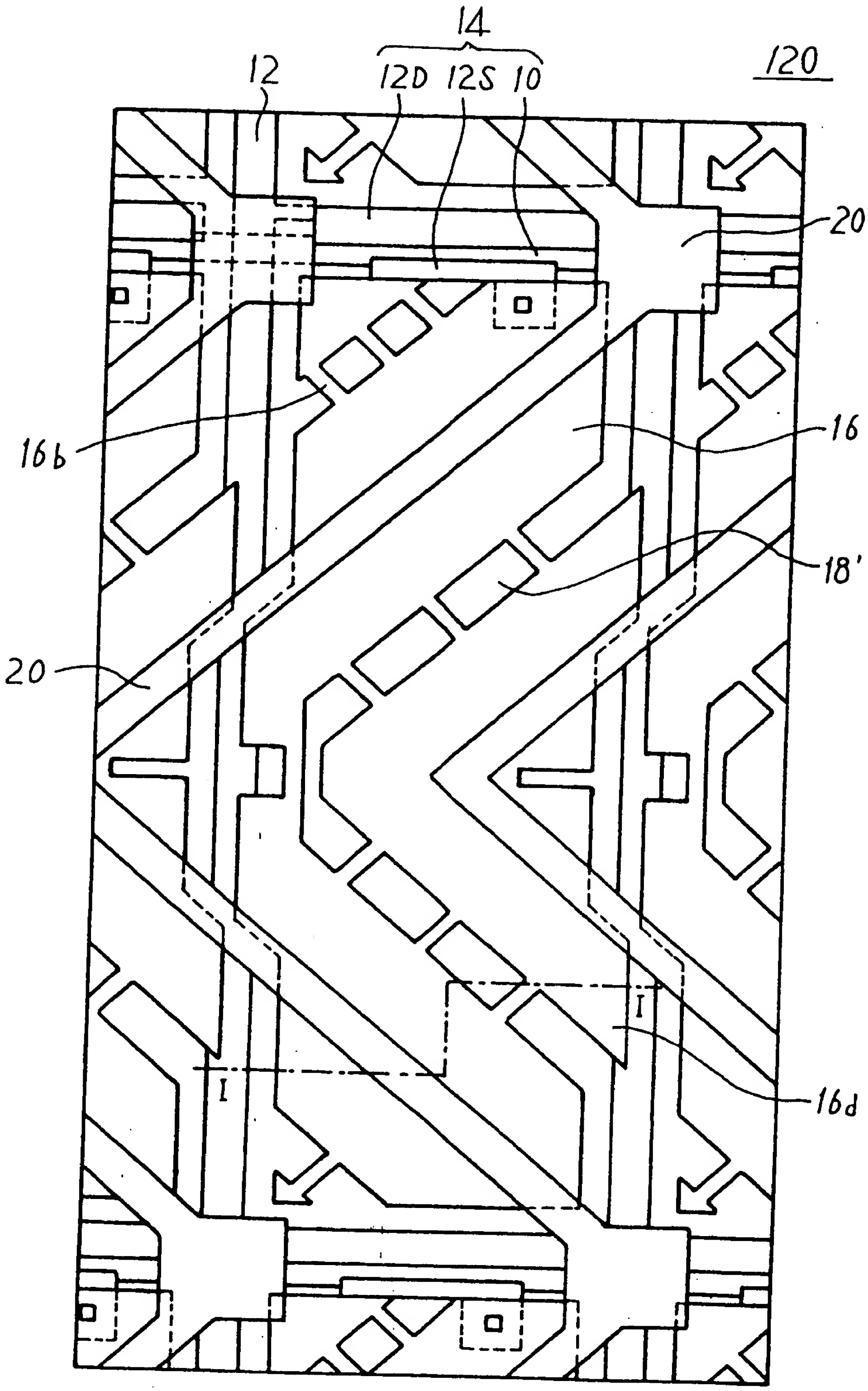
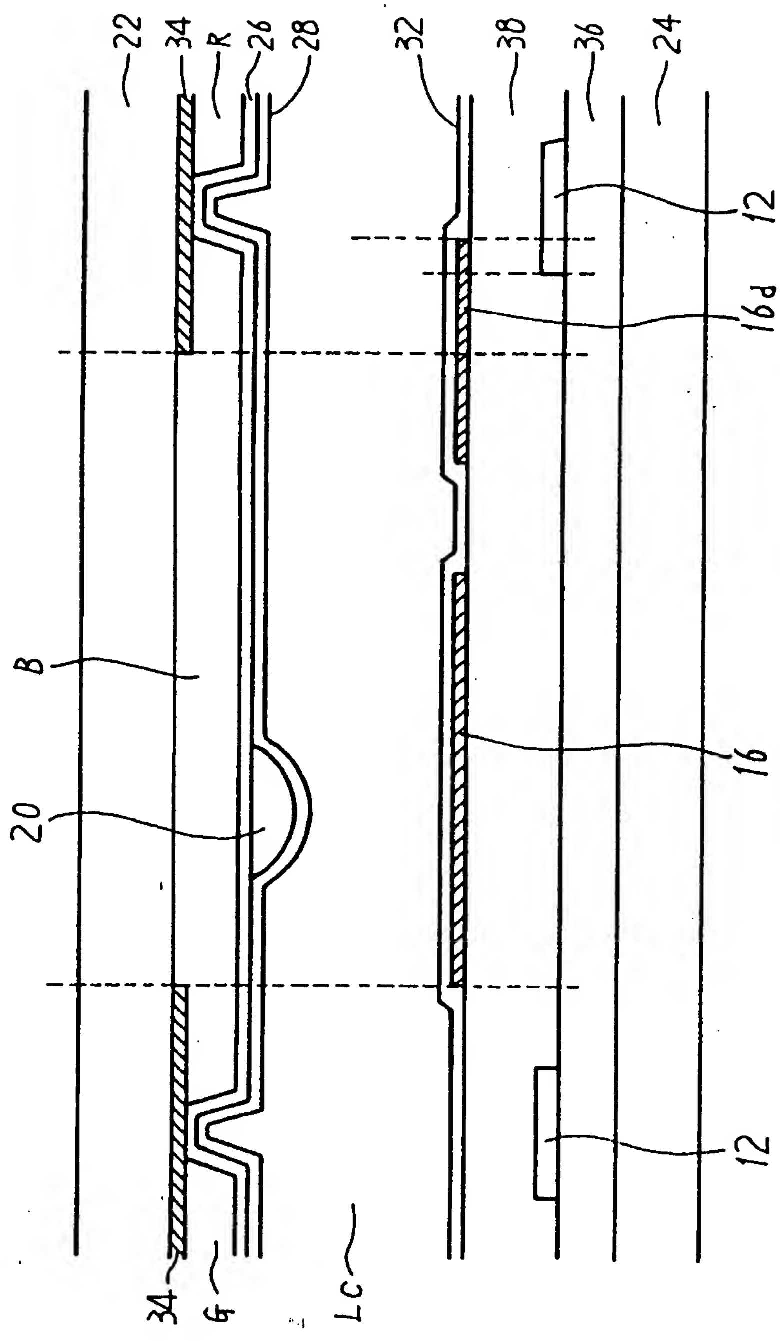


FIG. 7



F I G. 8

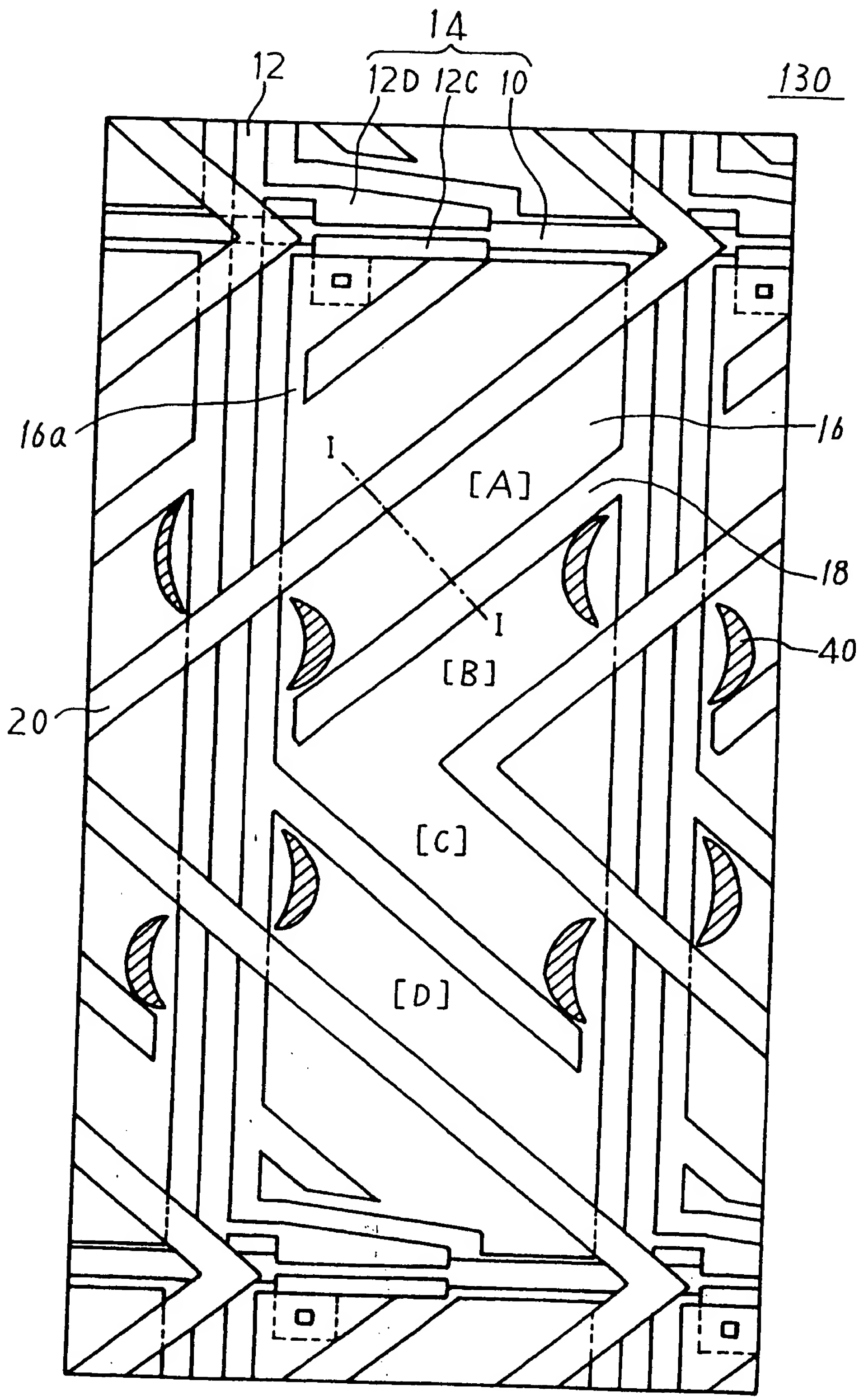
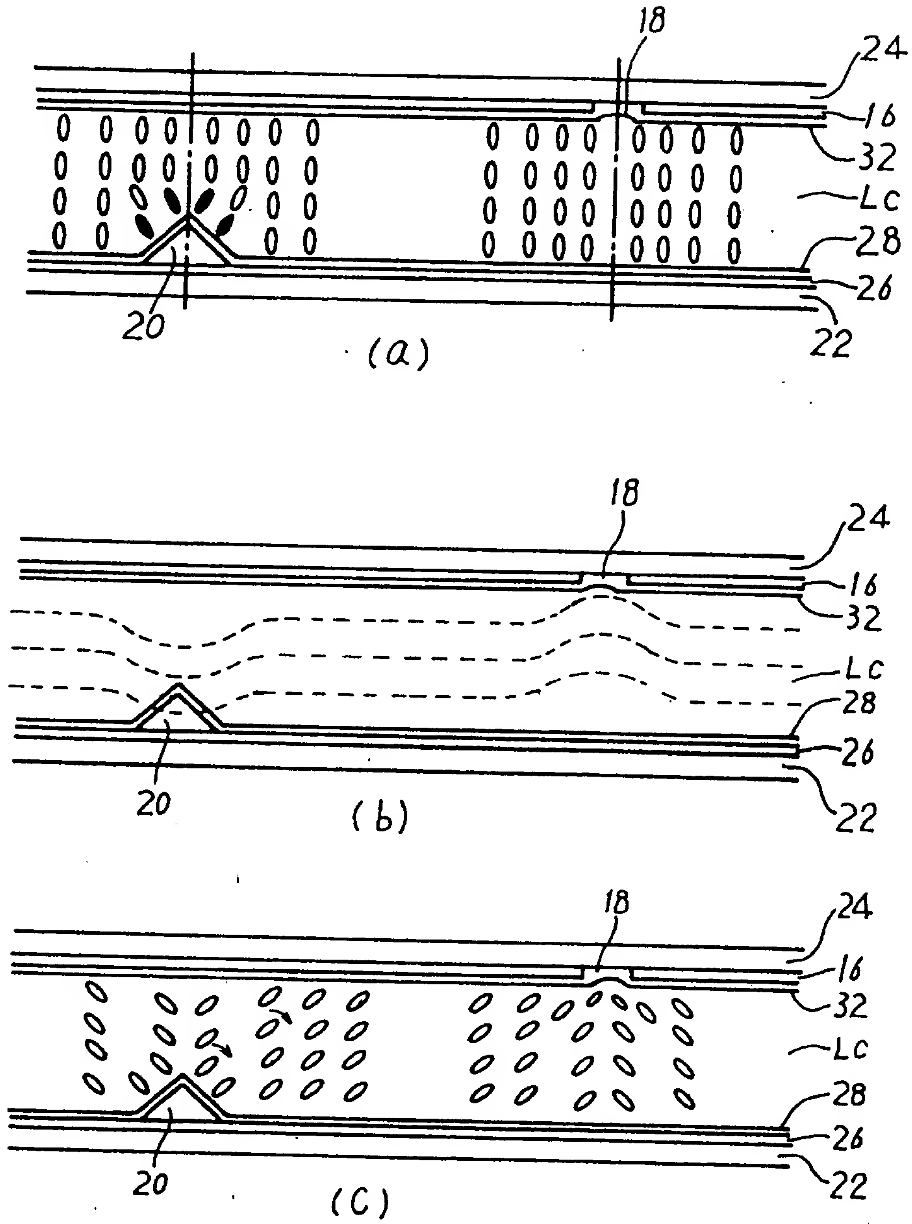


FIG. 9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Lc
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26
22
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(a)
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18
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Lc
28
26
22
20
(C)

FIG. 10

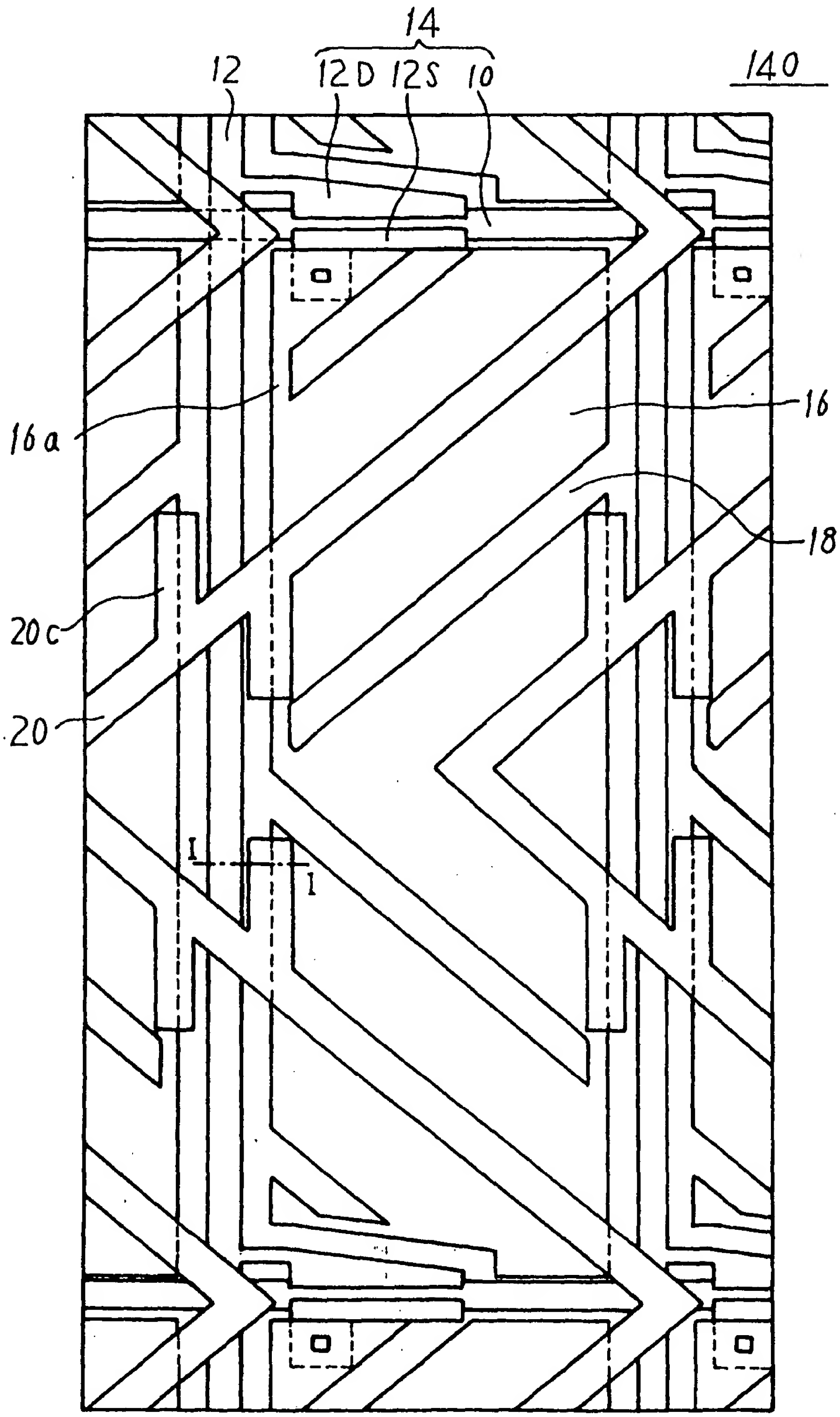


FIG. 11

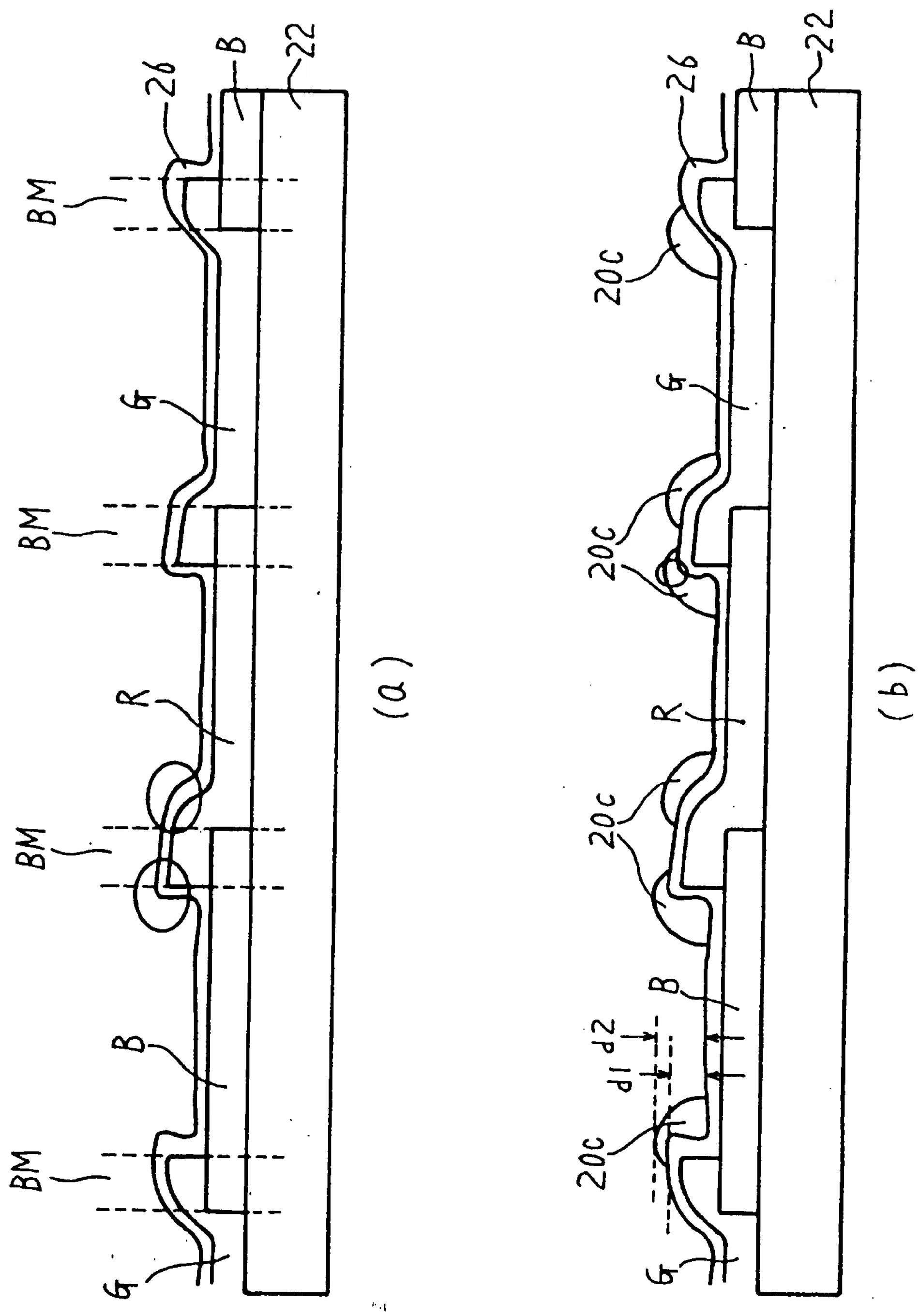
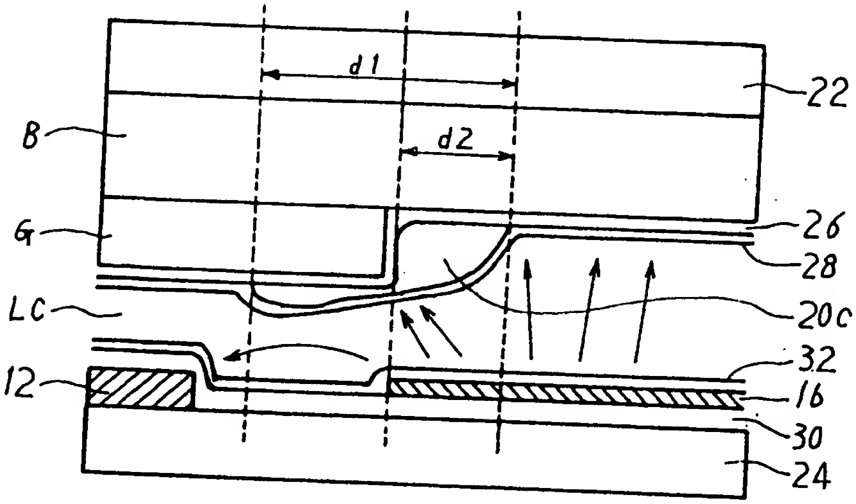


FIG. 12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d2
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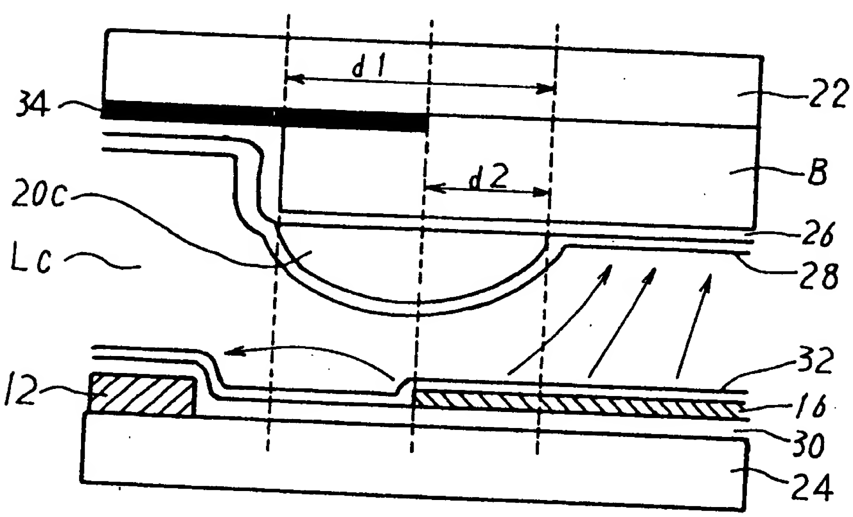
B
G
26
28
Lc
20c
32
12
16
30
24

(a)


d1
d2
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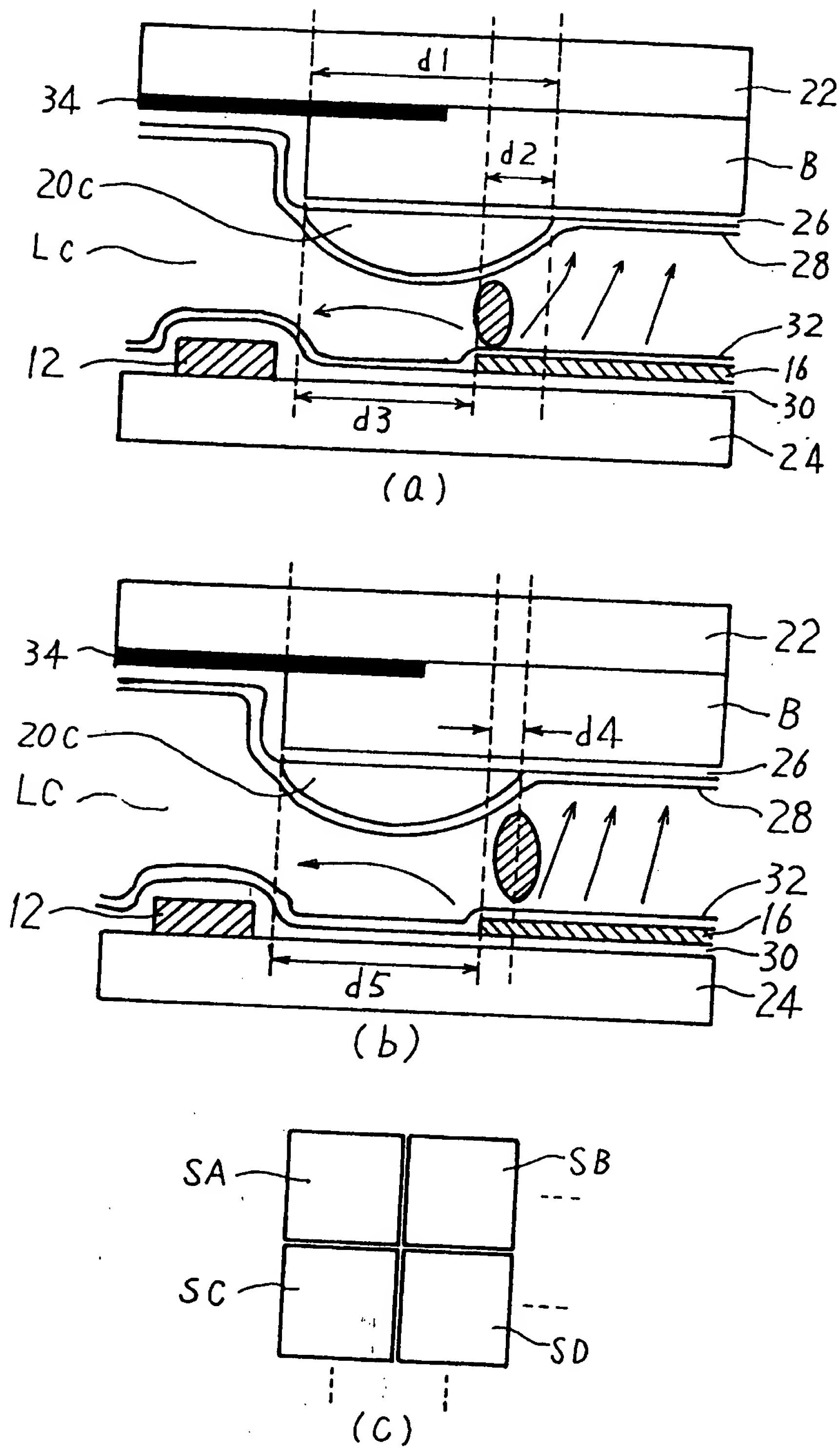
22
B
20c
26
Lc
28
32
12
16
30
24

(b)

FIG. 13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20c
Lc
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d1
d2
d3
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B
26
28
32
16
30
24
(a)
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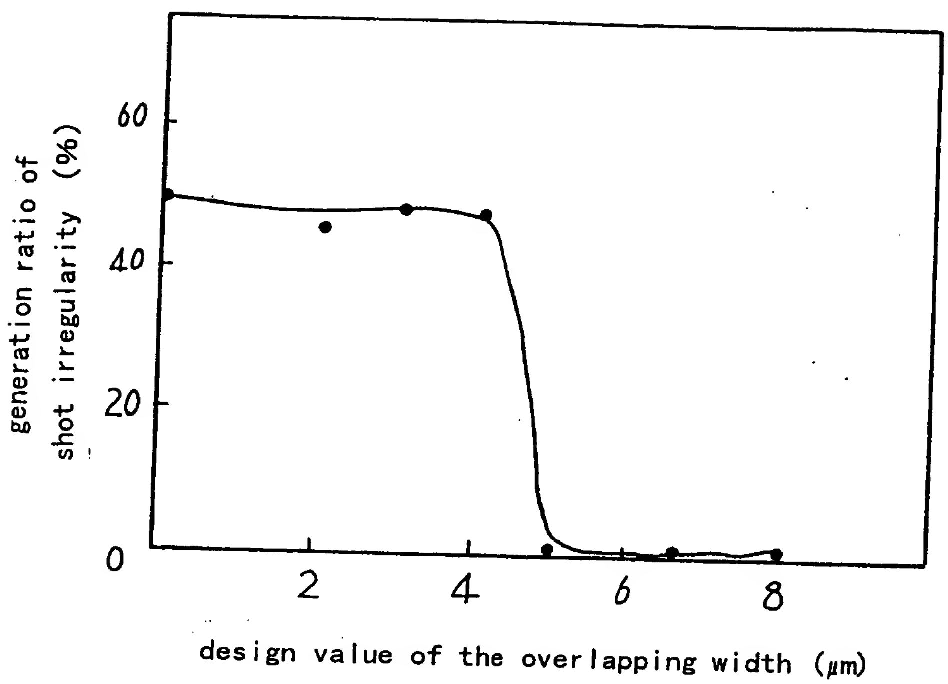
20c
LC
12
d4
d5
22
B
26
28
32
16
30
24
(b)
SA
SB
SC
SD
(c)

FIG. 14


60
40
20
0
2
4
6
8
generation ratio of
shot irregularity (%)
design value of the overlapping width (μm)

[Name of Document] ABSTRACT

[Summary]

[Problem]

An MVA liquid crystal display which is high in brightness and has preferable characteristics is provided. Further, the MVA liquid crystal display with a preferable display quality as well as a larger margin in fabrication and a higher yield is provided.

[Solving Means]

A first substrate having a first electrode, a second substrate having a second electrode corresponding to a display pixel, the liquid crystal having negative dielectric anisotropy sealed between the first and the second substrates, and a structure which is provided on each of the first and the second substrate to control an alignment of the liquid crystal are provided. The structure in the first substrate has a linear protrusion structure and provides at least two auxiliary protrusion structures opposing to each end portion facing to the second electrode extending from a protrusion structure provided and the width between the two auxiliary protrusions and the opposing second electrode is 6 μm or more respectively.

[Selected Figure] Fig. 1